Inoculative versus Inundative Release/Application Strategies Using Microbes for Pest Management

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MAJOR RELEASE STRATEGIES

- **Classical biological control**
  - Exotic pathogen introduced for permanent establishment and long-term control
- **Inoculative release of domestic pathogen**
  - Domestic pathogen introduced for short and long term control
- **Inundative release**
  - Short term impact expected from the microbes released (= biopesticides, chemical paradigm)

ECOLOGY OF STRATEGIES

	Classical biological control	Inoculative augmentation	Inundative release
Establishment & persistence	Required [and spread is good too]	Establishes and persists at least long enough for impact	Transient occurrence
Horizontal transmission	Required	Required	Not necessary
Amount released	Usually limited	Can be limited	Lots
Time frame	Long-term, permanent	Long enough for impact	Short term

STRATEGIES FOR USING MICROBES BY ARTHROPOD, WEEDS, PLANT PATHOGENS

	Classical biological control	Inoculative augmentation	Inundative release
Arthropods	+	+	+++
Weeds	+++	+	++
Plant pathogens	+ (very little)	+++	++

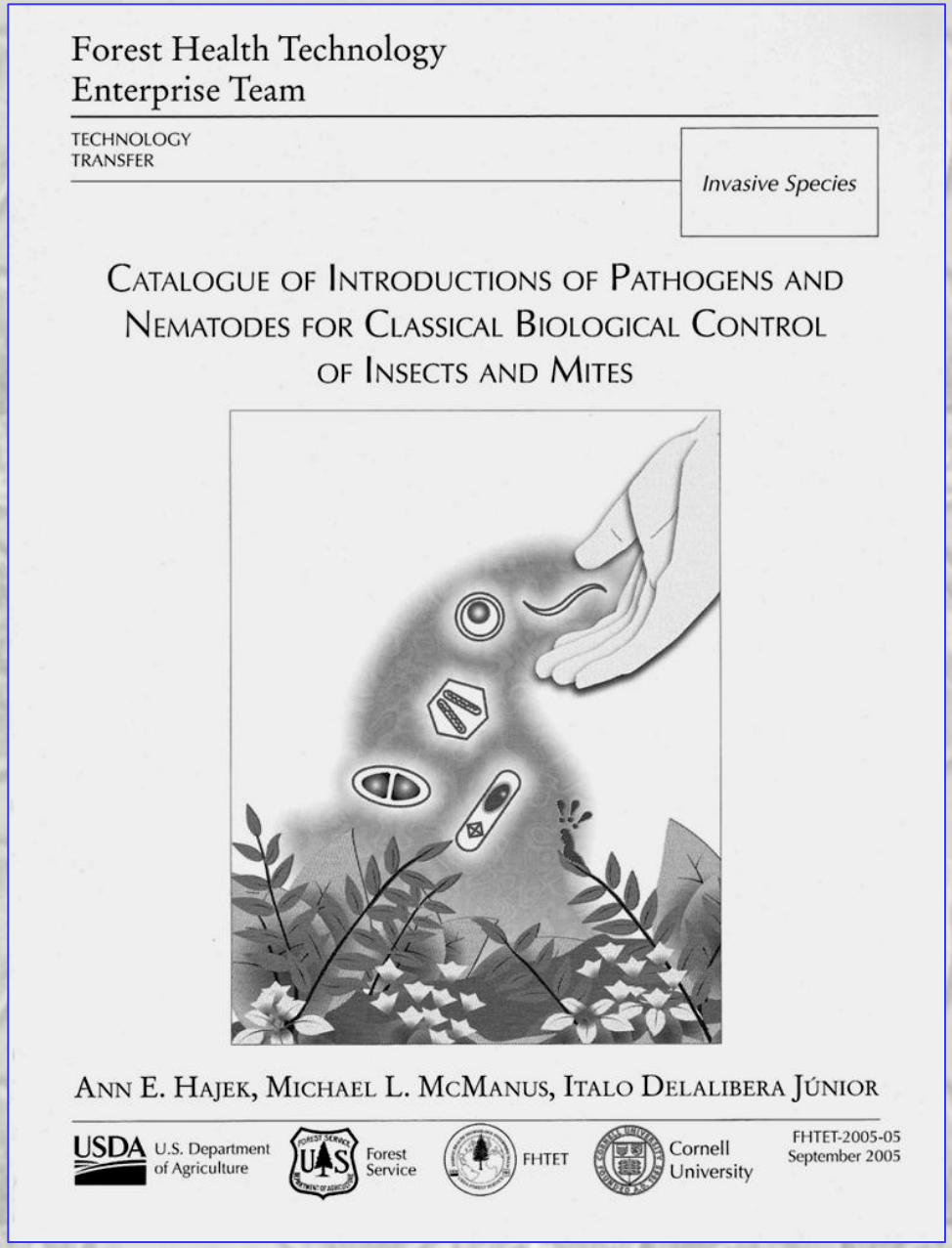
CLASSICAL BIOLOGICAL CONTROL PROGRAMS

ARTHROPOD PESTS	
Parasitoids and predators (BIOCAT)	5393
Pathogens and nematodes	131
WEEDS (Julien & Griffiths 1998)	
Vertebrates and arthropods	918
Fungi and nematodes	31

133 programs, mostly since 1950

# programs	
Virus	32
Bacteria	6
Fungi	71
Protists	1
Nematodes	29

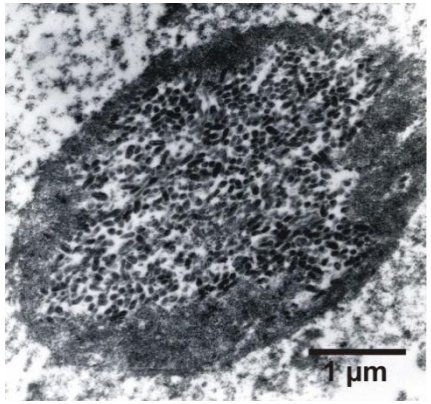
Often these pathogens are difficult to mass produce but are known to cause epizootics



Hard copies are available from the USDA, Forest Service. Lisa Cress at: lcress@fs.fed.us
http://www.fs.fed.us/foresthealth/technology/pdfs/catalogue.pdf

Success with *Oryctes rhinoceros* (Palm rhinoceros beetle)

- Introduced to many palm-growing areas in the southeastern Asia and India
- Damage and kill palm trees
- Nudivirus from native beetles in Malaysia

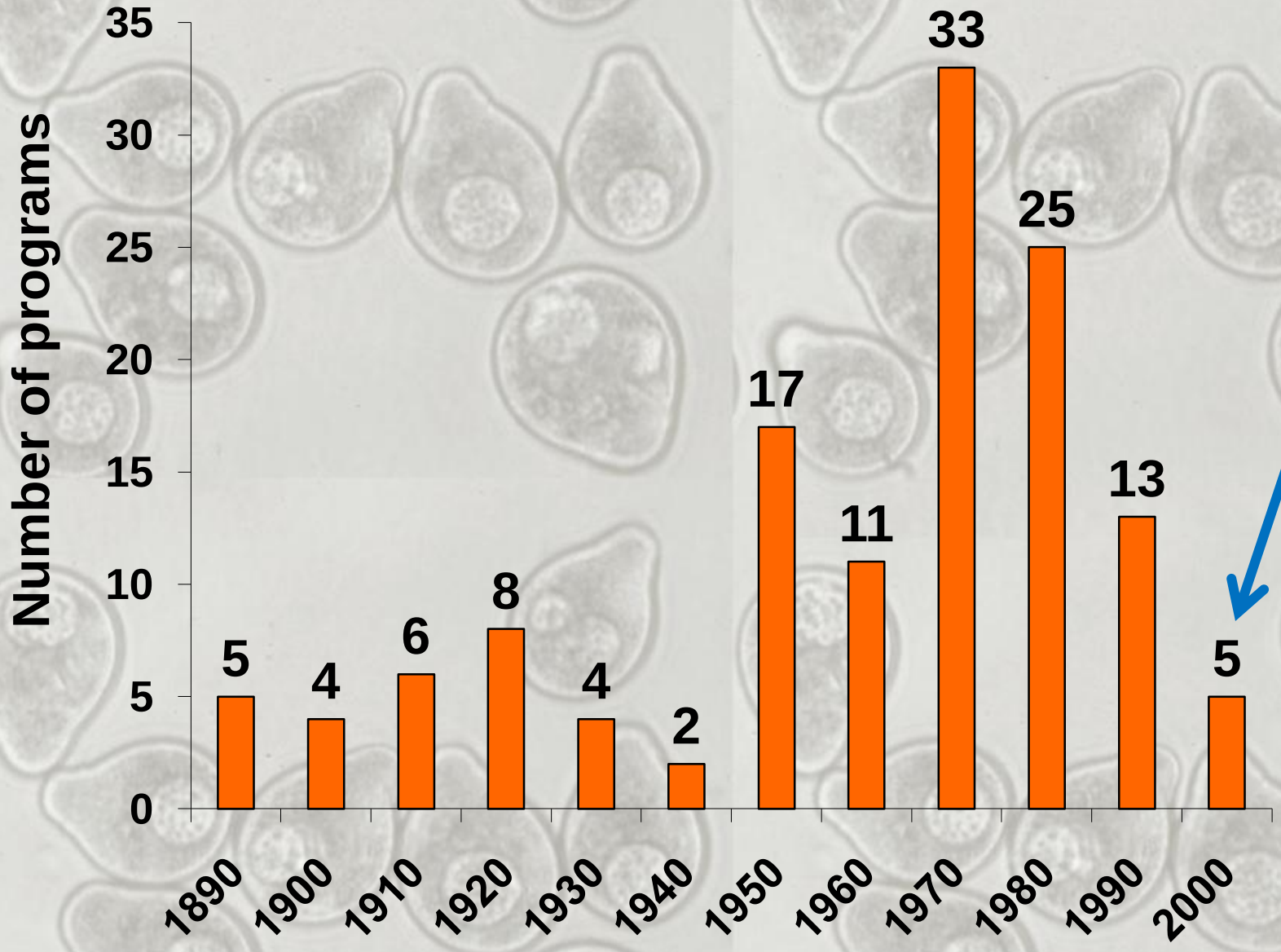


Released virus in 13 island groups over 21 years

- Highly successful; pest populations and damage decreased
- Limited reports that beetle resurgence can occur--probably because this virus does not persist well when beetles are not present.

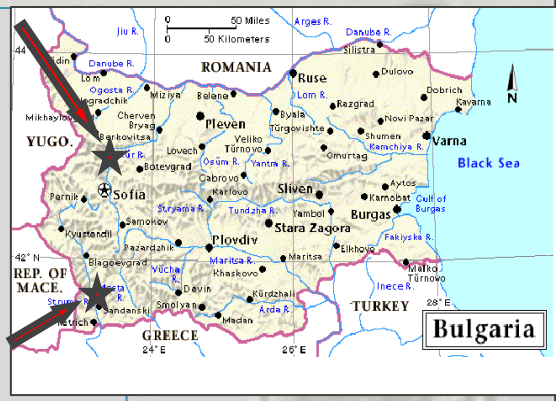
Oil palm plantations

Worldwide classical biological control programs using microbes against arthropods



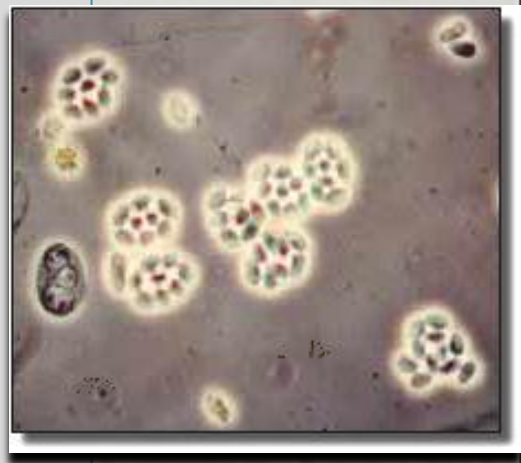
The only microbial/arthropod CBC introduction in the US since 1995

Two species of microsporidia against gypsy moth, *Lymantria dispar*



1. APHIS, PPQ permit to import
2. Produce data for NAPPO

   (ID of pathogens/host specificity in lab and in the field in Bulgaria = 14 years)
3. Submit petition to APHIS, PPQ
4. Submit petition to NAPPO for recommendation
5. Recommendation to EPA and APHIS
6. APHIS, EPA and State approval for release
7. PPQ 526 permit filed for release
8. Released in 2008



After local establishment …then what….?

- Classical biological control introductions:
  - often little inoculum is released in few places
- The pathogen is established and will eventually spread on its own (e.g., *Entomophaga maimaiga* against gypsy moth)
- But, after a classical biological control introduction, there's desire to assist spread to more areas, especially if the agent is effective.
- Land managers and the public can be very vocal and aggressive about assisting spread….
- Regulatory issues…how do you regulate this?

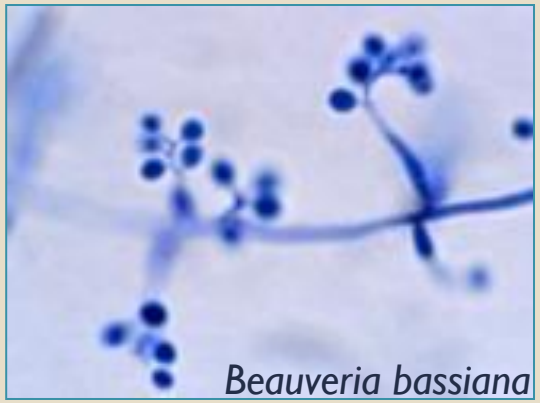
Inundative releases

Characteristics of pathogens used:

- Must be able to mass produce cheaply
  (or, in some cases, field-collected microbes are used if abundant)
- Must have acceptable shelf life and ability to transport
- Hopefully, impact is rapid after release (generally mortality of the pest)

‘ACTIVE’ PLUS ‘INACTIVE’ PRODUCTS)

- South America 42.7%
- North America 20.5% (13.5% USA)
- Europe 12.3%
- Asia 12.3%
- Central America 7.0%
- Africa 2.9%
- Oceania 2.3%



Beauveria bassiana

(Faria & Wraight 2007)

USA: 5 fungal species, 16 active products

Regulations: Limited use

- For field testing on < 10 acres/crop/year (new domestic pathogen or new use) = unregistered use

- For field testing ≥ 10 acres (domestic pathogen): ***Experimental Use Permit*** from EPA required
  - This takes 6 months for non-food uses
  - $5,000 processing fee (for smaller businesses?)
  - 'some' data will be needed, e.g., product characterization, some toxicity tests

Regulations: Biopesticide registration

- Federal Insecticide Fungicide and Rodenticide Act (FIFRA): 1972, amended 1996 – **EPA**

"no person in any state may distribute or sell to any person any pesticide that is not registered under this act"

So…for eventual registered use in the US, the product must be registered by the EPA.

Present estimate $2 million/isolate.

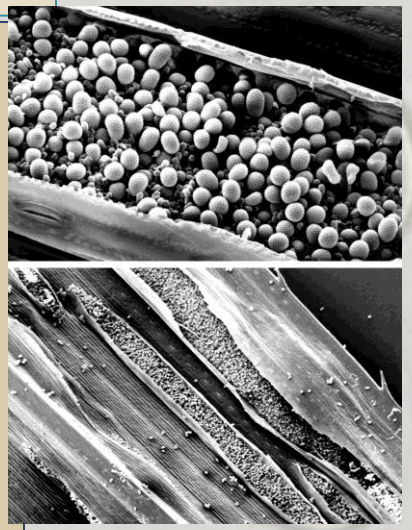
MAJOR RELEASE STRATEGIES

	Classical biological control	Inoculative augmentation	Inundative release
Persistence	Required [and spread is good]	Persists at least long enough for impact	Transient
Horizontal transmission	Required	Required for impact	Not necessary
Amount released	Limited	Limited	Lots
Time frame	Long-term, permanent	Long enough for impact	Short term

Why not use these for inundative releases?

Inoculative augmentation

Goal: Often to cause epizootics/epiphytotics earlier than usual



Rust against yellow nutsedge

Epiphytotics occur naturally in August or Sept.

Rust released in spring, before normally active

Rust decreases flowering and tuber formation

Product: Dr. BioSedge but not available now: mass production difficult/ price was high

Inoculative augmentation

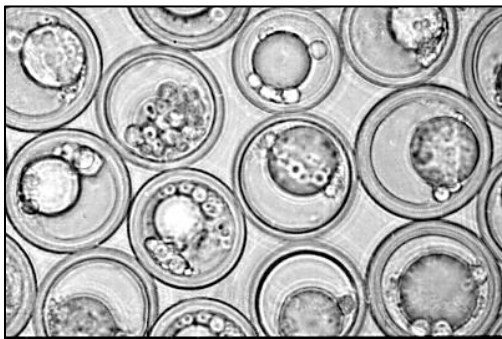
Goal: to cause epizootics earlier than usual

Entomophaga maimaiga released against gypsy moth

- Field collected soil containing resting spores from bases of oak trees in central NY
- APHIS & MD permits to release on eastern shore MD
- Releases in April1995 & 1996
- Late instar larval survival (late June) lower in fungal release plots.

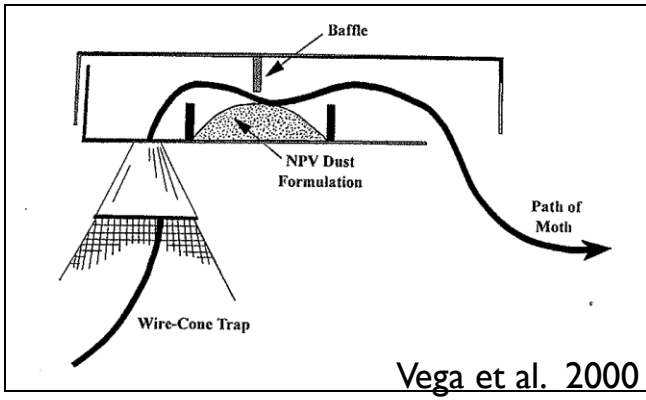
(Hajek & Webb 1999)

No product in sight.



Inoculative augmentation

Using dispersal of the pest for inoculation and horizontal transmission



Vega et al. 2000

Autodissemination traps

- Insect is attracted
- Enters trap
- Becomes inoculated with the pathogen
- Leaves trap

Goal: Inoculated insect carries inoculum to mates, conspecifics and the environment

NONE available commercially now

Fungal bands for control of longhorned beetles

Products sold in Japan & China
In development in the US

Asian longhorned beetle adults:

- Contact fiber bands containing cultures of entomopathogenic fungi (attractants present)
- Walk across fungal band, acquiring spores
  - Infection andmortality
  - Can transmit conidia after leaving

Inoculative augmentation: Regulations

This strategy has been **used** relatively little in the U.S.

- Generally little inoculum is released
- The goal is for longer term activity, like a classical biological control agent

Unlike classical biological control, this use would require full registration, as a biopesticide (under FIFRA = EPA)
[Microbes for use in classical biological control don't go through the biopesticide registration process]

In our work with Asian longhorned beetles (inoculative augmentation using fungal bands), we realized that we could only use fungal strains already registered by EPA

Back to the Future

Classical biological control

- Should use/could use microbes more

Inundative releases

- Very expensive to develop new strains/species, especially relative to limited markets

Inoculative augmentation – arthropods/weeds

- Some methods show promise but few are used in the US--regulated the same as inundative (which could restrict use)

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